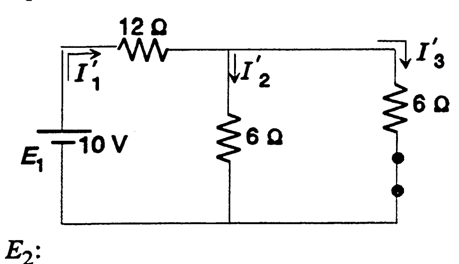
CHAPTER 9 (Odd)

1. a. E_1:



E_2:

$$I'_1 = \frac{10\text{ V}}{12\ \Omega + 6\ \Omega \| 6\ \Omega} = \frac{10\text{ V}}{12\ \Omega + 3\ \Omega} = \frac{2}{3}\text{ A}$$

$$I'_2 = I'_3 = \frac{I'_1}{2} = \frac{1}{3}\text{ A}$$

$$I''_3 = \frac{5\text{ V}}{6\ \Omega + 6\ \Omega \| 12\ \Omega} = \frac{5\text{ V}}{6\ \Omega + 4\ \Omega} = \frac{1}{2}\text{ A}$$

$$I''_1 = \frac{6\ \Omega(I''_3)}{6\ \Omega + 12\ \Omega} = \frac{1}{6}\text{ A}$$

$$I''_2 = \frac{12\ \Omega(I''_3)}{12\ \Omega + 6\ \Omega} = \frac{1}{3}\text{ A}$$

$$I_1 = I'_1 + I''_1 = \frac{2}{3}\text{ A} + \frac{1}{6}\text{ A} = \mathbf{\frac{5}{6}\text{ A}}$$

$$I_2 = I'_2 - I''_2 = \frac{1}{3}\text{ A} - \frac{1}{3}\text{ A} = \mathbf{0\text{ A}}$$

$$I_3 = I'_3 + I''_3 = \frac{1}{3}\text{ A} + \frac{1}{2}\text{ A} = \mathbf{\frac{5}{6}\text{ A}}$$

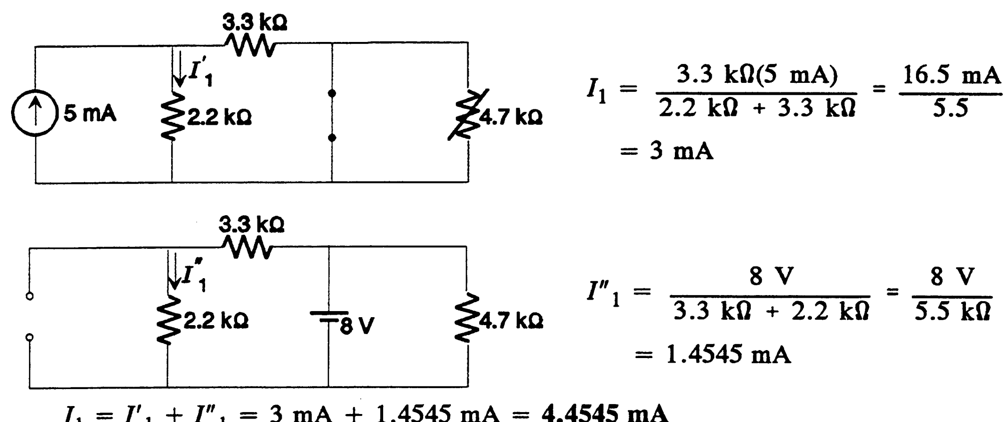
b. E_1: $P'_1 = I'^2_1 R_1 = \left(\frac{2}{3}\text{ A}\right)^2 12\ \Omega = \mathbf{5.333\text{ W}}$

E_2: $P''_1 = I''^2_1 R_1 = \left(\frac{1}{6}\text{ A}\right)^2 12\ \Omega = \mathbf{0.333\text{ W}}$

c. $P_1 = I_1^2 R_1 = \left(\frac{5}{6}\text{ A}\right)^2 12\ \Omega = \mathbf{8.333\text{ W}}$

d. $P'_1 + P''_1 = 5.333\text{ W} + 0.333\text{ W} = 5.666\text{ W} \neq 8.333\text{ W} = P_1$

3. a.

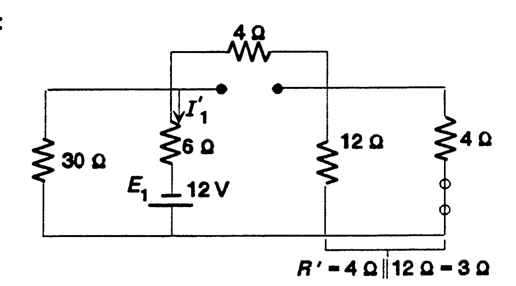


$$I_1 = \frac{3.3\text{ k}\Omega(5\text{ mA})}{2.2\text{ k}\Omega + 3.3\text{ k}\Omega} = \frac{16.5\text{ mA}}{5.5} = 3\text{ mA}$$

$$I''_1 = \frac{8\text{ V}}{3.3\text{ k}\Omega + 2.2\text{ k}\Omega} = \frac{8\text{ V}}{5.5\text{ k}\Omega} = 1.4545\text{ mA}$$

$$I_1 = I'_1 + I''_1 = 3\text{ mA} + 1.4545\text{ mA} = \mathbf{4.4545\text{ mA}}$$

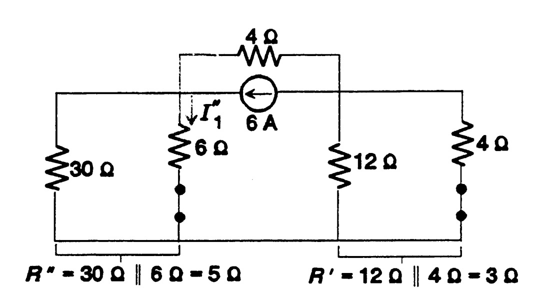
b. E_1:

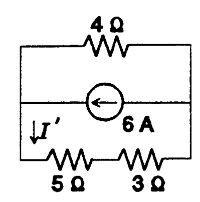


I'1
6 Ω
E 12 V
7 Ω
30 Ω
R" = 7 Ω ∥ 30 Ω = 5.6757

$$I'_1 = \frac{E_1}{R_T} = \frac{12\text{ V}}{6\ \Omega + 5.6757\ \Omega} = 1.0278\text{ A}$$

I:

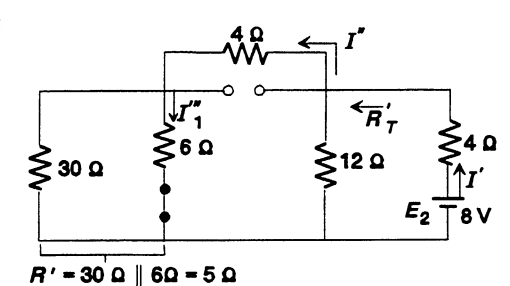




$$I' = \frac{4\ \Omega(6\text{ A})}{4\ \Omega + 8\ \Omega} = 2\text{ A}$$

$$I''_1 = \frac{30\ \Omega(2\text{ A})}{30\ \Omega + 6\ \Omega} = 1.667\text{ A}$$

E_2:



$$R'_T = 12\ \Omega \parallel (4\ \Omega + 5\ \Omega) = 12\ \Omega \parallel 9\ \Omega = 5.143\ \Omega$$

$$I' = \frac{E_2}{R_T} = \frac{8\text{ V}}{4\ \Omega + 5.143\ \Omega} = 0.875\text{ A}$$

$$I'' = \frac{12\ \Omega(I')}{12\ \Omega + 9\ \Omega} = \frac{12\ \Omega(0.875\text{ A})}{21\ \Omega} = 0.5\text{ A}$$

$$I'''_1 = \frac{30\ \Omega(I'')}{30\ \Omega + 6\ \Omega} = \frac{30\ \Omega(0.5\ \text{A})}{36\ \Omega} = 0.4167\ \text{A}$$

$$I_1 = I_{R_1} = I'_1 + I''_1 + I'''_1$$
$$= 1.0278\ \text{A} + 1.667\ \text{A} + 0.4167\ \text{A} = \mathbf{3.11\ A}$$

5. a. $R_{Th} = R_3 + R_1 \| R_2 = 4\ \Omega + 6\ \Omega \| 3\ \Omega = 4\ \Omega + 2\ \Omega = \mathbf{6\ \Omega}$

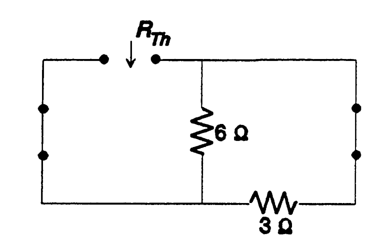
$$E_{Th} = \frac{R_2 E}{R_2 + R_1} = \frac{3\ \Omega(18\ \text{V})}{3\ \Omega + 6\ \Omega} = \mathbf{6\ V}$$

b. $I_1 = \dfrac{E_{Th}}{R_{Th} + R} = \dfrac{6\ \text{V}}{6\ \Omega + 2\ \Omega} = \mathbf{0.75\ A}$

$$I_2 = \frac{6\ \text{V}}{6\ \Omega + 30\ \Omega} = \mathbf{0.1667\ A}$$

$$I_3 = \frac{6\ \text{V}}{6\ \Omega + 100\ \Omega} = \mathbf{0.0566\ A}$$

7. (I): R_{Th}:

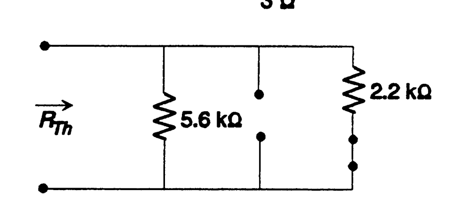


$R_{Th} = 6\ \Omega \| 3\ \Omega = \mathbf{2\ \Omega}$

E_{Th}:

$$V = \frac{6\ \Omega(18\ \text{V})}{6\ \Omega + 3\ \Omega} = 12\ \text{V}$$
$$E_{Th} = 72\ \text{V} + \text{V} = \mathbf{84\ V}$$

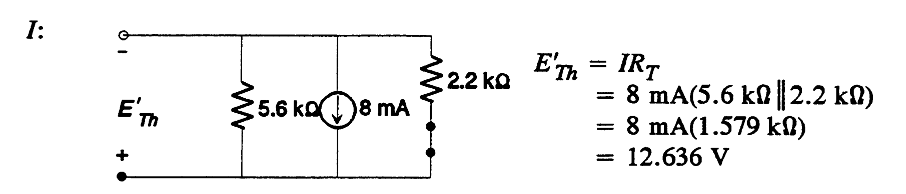
(II): R_{Th}:



$R_{Th} = 5.6\ \text{k}\Omega \| 2.2\ \text{k}\Omega = \mathbf{1.579\ k\Omega}$

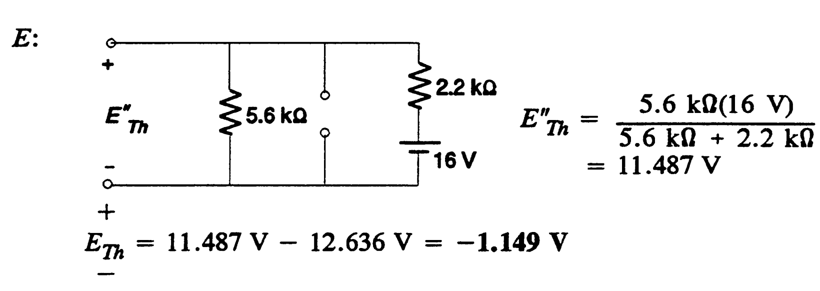
E_{Th}: Superposition:

I:



$E'_{Th} = IR_T$
$= 8\ \text{mA}(5.6\ \text{k}\Omega \| 2.2\ \text{k}\Omega)$
$= 8\ \text{mA}(1.579\ \text{k}\Omega)$
$= 12.636\ \text{V}$

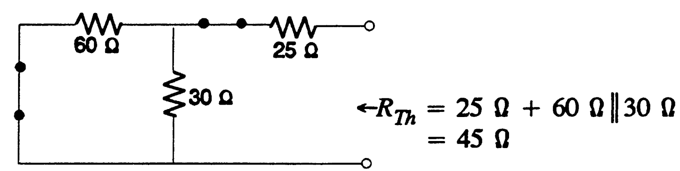
E:



$$E''_{Th} = \frac{5.6\text{ k}\Omega(16\text{ V})}{5.6\text{ k}\Omega + 2.2\text{ k}\Omega} = 11.487\text{ V}$$

$$E_{Th} = 11.487\text{ V} - 12.636\text{ V} = \mathbf{-1.149\text{ V}}$$

9. (I): R_{Th}:



$$R_{Th} = 25\ \Omega + 60\ \Omega \| 30\ \Omega = 45\ \Omega$$

E_{Th}:

$$E_{Th} = V_{30\Omega} - 10\text{ V} - 0 = \frac{30\ \Omega(15\text{ V})}{30\ \Omega + 60\ \Omega} - 10\text{ V} = 5\text{ V} - 10\text{ V} = \mathbf{-5\text{ V}}$$

(II): R_{Th}:

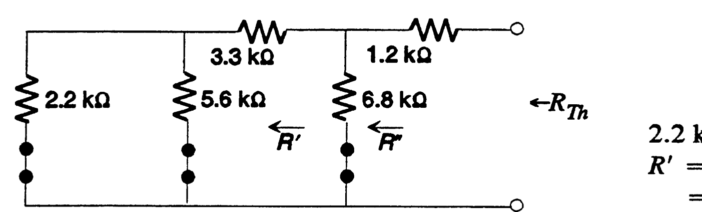
$$R_{Th} = 2.7\text{ k}\Omega \| (4.7\text{ k}\Omega + 3.9\text{ k}\Omega) = 2.7\text{ k}\Omega \| 8.6\text{ k}\Omega = \mathbf{2.055\text{ k}\Omega}$$

E_{Th}:

$$I' = \frac{3.9\text{ k}\Omega(18\text{ mA})}{3.9\text{ k}\Omega + 7.4\text{ k}\Omega} = 6.212\text{ mA}$$

$$E_{Th} = I'(2.7\text{ k}\Omega) = (6.212\text{ mA})(2.7\text{ k}\Omega) = \mathbf{16.772\text{ V}}$$

11. R_{Th}:



$2.2\text{ k}\Omega \parallel 5.6\text{ k}\Omega = 1.579\text{ k}\Omega$
$R' = 1.579\text{ k}\Omega + 3.3\text{ k}\Omega$
$= 4.879\text{ k}\Omega$

$R'' = 4.879\text{ k}\Omega \parallel 6.8\text{ k}\Omega = 2.841\text{ k}\Omega$
$R_{Th} = 1.2\text{ k}\Omega + R'' = 1.2\text{ k}\Omega + 2.841\text{ k}\Omega = \mathbf{4.041\text{ k}\Omega}$

E_{Th}: Source conversions:

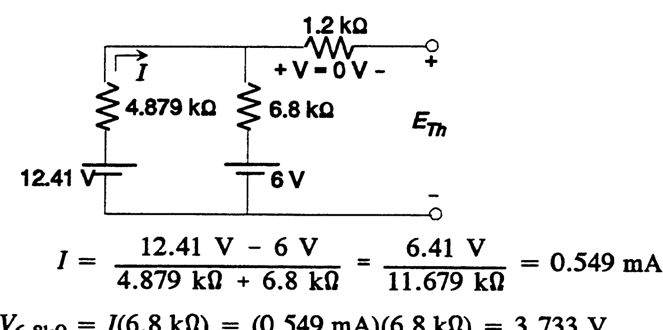
$$I_1 = \frac{22\text{ V}}{2.2\text{ k}\Omega} = 10\text{ mA},\ R_s = 2.2\text{ k}\Omega$$

$$I_2 = \frac{12\text{ V}}{5.6\text{ k}\Omega} = 2.143\text{ mA},\ R_s = 5.6\text{ k}\Omega$$

Combining parallel current sources: $I'_T = I_1 - I_2 = 10\text{ mA} - 2.143\text{ mA} = 7.857\text{ mA}$

$2.2\text{ k}\Omega \parallel 5.6\text{ k}\Omega = 1.579\text{ k}\Omega$

Source conversion:
$E = (7.857\text{ mA})(1.579\text{ k}\Omega) = 12.41\text{ V}$
$R' = R_s + 3.3\text{ k}\Omega = 1.579\text{ k}\Omega + 3.3\text{ k}\Omega = 4.879\text{ k}\Omega$

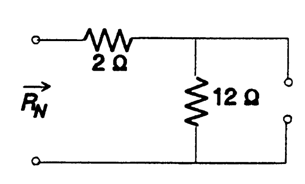


$$I = \frac{12.41\text{ V} - 6\text{ V}}{4.879\text{ k}\Omega + 6.8\text{ k}\Omega} = \frac{6.41\text{ V}}{11.679\text{ k}\Omega} = 0.549\text{ mA}$$

$$V_{6.8\text{k}\Omega} = I(6.8\text{ k}\Omega) = (0.549\text{ mA})(6.8\text{ k}\Omega) = 3.733\text{ V}$$

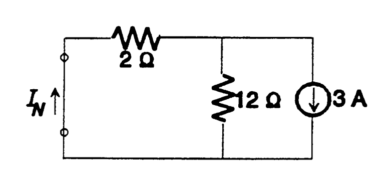
$$E_{Th} = 6\text{ V} + V_{6.8\text{k}\Omega} = 6\text{ V} + 3.733\text{ V} = \mathbf{9.733\text{ V}}$$

13. (I) R_N:



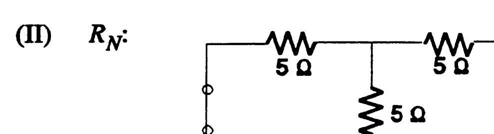
$R_N = 2\ \Omega + 12\ \Omega = \mathbf{14\ \Omega}$

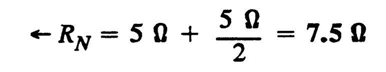
I_N:



$$I_N = \frac{12\ \Omega(3\text{ A})}{12\ \Omega + 2\ \Omega} = \mathbf{2.571\text{ A}}$$

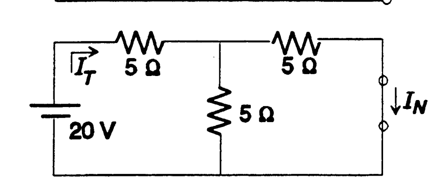
(II) R_N:





$\leftarrow R_N = 5\ \Omega + \frac{5\ \Omega}{2} = \mathbf{7.5\ \Omega}$

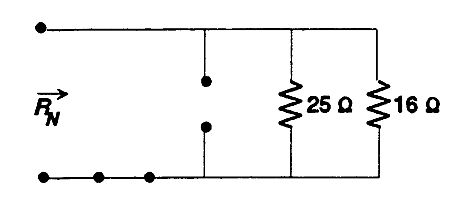
I_N:



$$I_T = \frac{20\ V}{5\ \Omega + \frac{5\ \Omega}{2}} = 2.667\ A$$

$$I_N = \frac{I_T}{2} = \mathbf{1.333\ A}$$

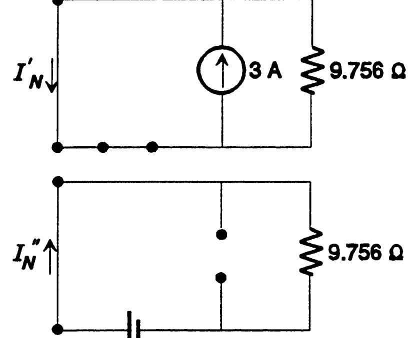
15. (a)



$R_N = 25\ \Omega \parallel 16\ \Omega = \mathbf{9.756\ \Omega}$

I_N: Superposition:

I:



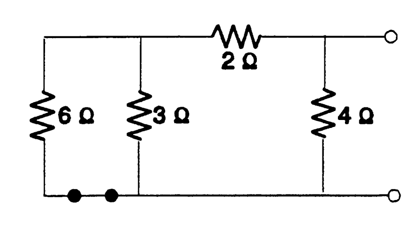
$I'_N = 3$ A

E:

$$I''_N = \frac{20\ V}{9.756\ \Omega} = 2.05\ A$$

$I_N = I'_N - I''_N = 3\ A - 2.05\ A = \mathbf{0.95\ A}$ (direction of I'_N)

(b) R_N:



$\leftarrow R_N = 4\ \Omega \parallel (2\ \Omega + 2\ \Omega) = \mathbf{2\ \Omega}$

I_N:

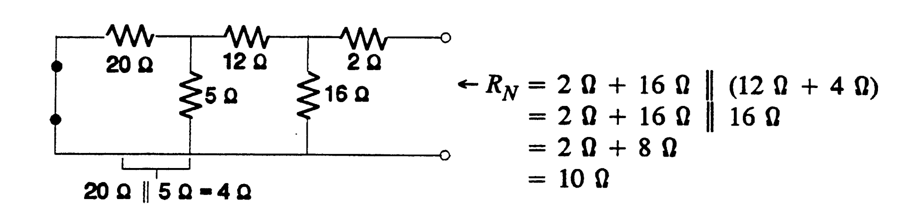
$$I = \frac{72 \text{ V}}{4 \ \Omega \| (3 \ \Omega + 6 \ \Omega \| 2 \ \Omega)} = \frac{72 \text{ V}}{2.118 \ \Omega} \cong 34 \text{ A}$$

$$I_1 = \frac{4 \ \Omega(I)}{4 \ \Omega + 4.5 \ \Omega} = 16 \text{ A}$$

$$I_2 = \frac{2 \ \Omega(I_1)}{2 \ \Omega + 6 \ \Omega} = 4 \text{ A}$$

$$I_N = I - I_2 = 34 \text{ A} - 4 \text{ A} = \mathbf{30 \text{ A}}$$

17. (a) R_N:



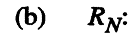
$$\leftarrow R_N = 2 \ \Omega + 16 \ \Omega \ \| \ (12 \ \Omega + 4 \ \Omega) = 2 \ \Omega + 16 \ \Omega \ \| \ 16 \ \Omega = 2 \ \Omega + 8 \ \Omega = 10 \ \Omega$$

I_N:

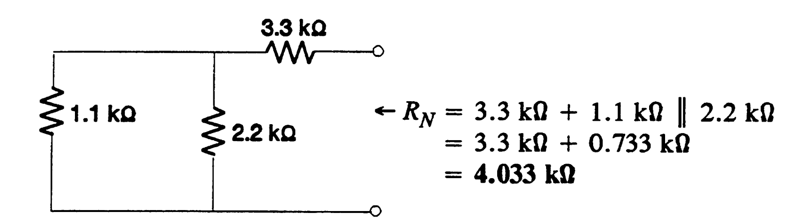
$$I = \frac{E}{R_T} = \frac{20 \text{ V}}{20 \ \Omega + 3.669 \ \Omega} = 0.845 \text{ A}$$

$$I_1 = \frac{5 \ \Omega(0.845 \text{ A})}{5 \ \Omega + 13.778 \ \Omega} = 0.225 \text{ A}$$

$$I_N = \frac{16 \ \Omega(0.225 \text{ A})}{16 \ \Omega + 2 \ \Omega} = \mathbf{0.2 \text{ A}}$$



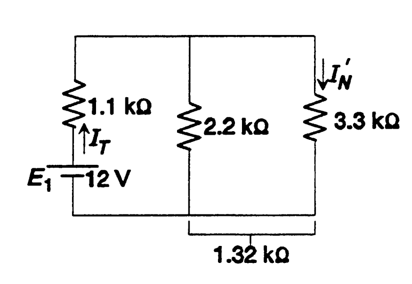
(b) R_N:



$$\leftarrow R_N = 3.3 \text{ k}\Omega + 1.1 \text{ k}\Omega \ \| \ 2.2 \text{ k}\Omega = 3.3 \text{ k}\Omega + 0.733 \text{ k}\Omega = \mathbf{4.033 \text{ k}\Omega}$$

I_N: Superposition:

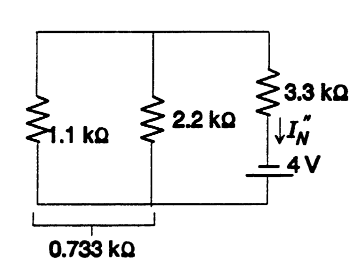
E_1:



$$I_T = \frac{12\text{ V}}{1.1\text{ k}\Omega + 1.32\text{ k}\Omega} = 4.959\text{ mA}$$

$$I'_N = \frac{2.2\text{ k}\Omega(4.959\text{ mA})}{2.2\text{ k}\Omega + 3.3\text{ k}\Omega} = 1.984\text{ mA}$$

E_2:



$$I''_N = \frac{4\text{ V}}{3.3\text{ k}\Omega + 0.733\text{ k}\Omega} = 0.9918\text{ mA}$$

$I_N = I'_N + I''_N = 1.984\text{ mA} + 0.9918\text{ mA} = \mathbf{2.9758\text{ mA}}$

19. a. (I) $R = R_{Th} = \mathbf{14\ \Omega}$
(II) $R = R_{Th} = \mathbf{7.5\ \Omega}$

b. (I) $P_{max} = E_{Th}^2/4R_{Th} = (36\text{ V})^2/4(14\ \Omega) = \mathbf{23.14\text{ W}}$
(II) $P_{max} = E_{Th}^2/4R_{Th} = (10\text{ V})^2/4(7.5\ \Omega) = \mathbf{3.33\text{ W}}$

21. a. $R = R_{Th} = \mathbf{9.756\ \Omega}$
b. $R = R_{Th} = \mathbf{2\ \Omega}$

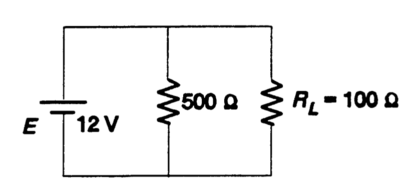
a. $P_{max} = E_{Th}^2/4R_{Th} = (9.268\text{ V})^2/4(9.756\ \Omega) = \mathbf{2.20\text{ W}}$
b. $P_{max} = E_{Th}^2/4R_{Th} = (60\text{ V})^2/4(2\ \Omega) = \mathbf{450\text{ W}}$

23. $P_{max} = \left[\dfrac{E_{Th}}{R_{Th} + R_4}\right]^2 R_4$

with $R_1 = \mathbf{0\ \Omega}$ E_{Th} is a maximum and R_{Th} a minimum

$\therefore$ P_{max} **a maximum**

25.



Since R_L fixed, maximum power to R_L when V_{R_L} a maximum as defined by $P_L = \dfrac{V_{R_L}^2}{R_L}$

$\therefore$ $R = \mathbf{500\ \Omega}$ and $P_{max} = \dfrac{(12\text{V})^2}{100\ \Omega} = 1.44\text{ W}$

27. $E_{eq} = \dfrac{-5\text{ V}/2.2\text{ k}\Omega + 20\text{ V}/8.2\text{ k}\Omega}{1/2.2\text{ k}\Omega + 1/8.2\text{ k}\Omega} = 0.2879\text{ V}$

$R_{eq} = \dfrac{1}{1/2.2\text{ k}\Omega + 1/8.2\text{ k}\Omega} = 1.7346\text{ k}\Omega$

$I_L = \dfrac{E_{eq}}{R_{eq} + R_L} = \dfrac{0.2879\text{ V}}{1.7346\text{ k}\Omega + 5.6\text{ k}\Omega} = \mathbf{39.3\ \mu A}$

$V_L = I_L R_L = (39.3\ \mu\text{A})(5.6\text{ k}\Omega) = \mathbf{220\text{ mV}}$

29. $I_{eq} = \dfrac{(4\text{ A})(4.7\ \Omega) + (1.6\text{ A})(3.3\ \Omega)}{4.7\ \Omega + 3.3\ \Omega} = \dfrac{18.8\text{ V} + 5.28\text{ V}}{8\ \Omega} = 3.01\text{ A}$

$R_{eq} = 4.7\ \Omega + 3.3\ \Omega = 8\ \Omega$

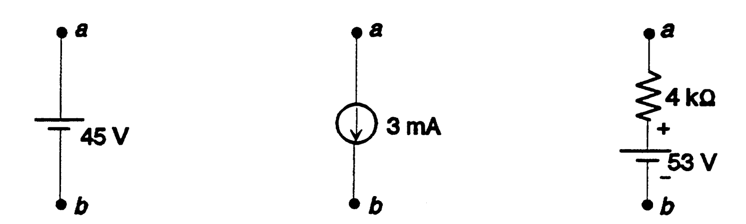
$I_L = \dfrac{R_{eq}(I_{eq})}{R_{eq} + R_L} = \dfrac{8\ \Omega(3.01\text{ A})}{8\ \Omega + 2.7\ \Omega} = \mathbf{2.25\text{ A}}$

$V_L = I_L R_L = (2.25\text{ A})(2.7\ \Omega) = \mathbf{6.075\text{ V}}$

31. $15\text{ k}\Omega \parallel (8\text{ k}\Omega + 7\text{ k}\Omega) = 15\text{ k}\Omega \parallel 15\text{ k}\Omega = 7.5\text{ k}\Omega$

$V_{ab} = \dfrac{7.5\text{k}\Omega(60\text{ V})}{7.5\text{ k}\Omega + 2.5\text{ k}\Omega} = 45\text{ V}$

$I_{ab} = \dfrac{45\text{ V}}{15\text{ k}\Omega} = 3\text{ mA}$



33.

I = 5 A

a

5 A 4 Ω 12 Ω 8 Ω 5 A

I = 0 A I = 0 A b I = 0 A

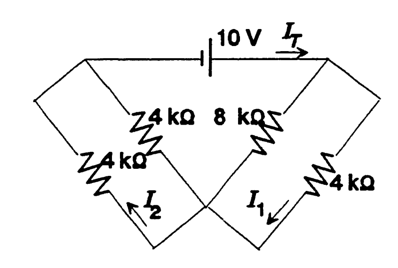
I = 5 A

$\therefore R_2$ = short-circuit, open-circuit, any value

$V_{ab} = 0\text{ V}$ (short)
$I_{ab} = 0\text{ A}$ (open)

R_2 any resistive value

35. (a)



$$I_T = \frac{10\text{ V}}{4\text{ k}\Omega \| 8\text{ k}\Omega + 4\text{ k}\Omega \| 4\text{ k}\Omega} = \frac{10\text{ V}}{2.667\text{ k}\Omega + 2\text{ k}\Omega} = \frac{10\text{ V}}{4.667\text{ k}\Omega} = 2.143\text{ mA}$$

$$I_1 = \frac{8\ \Omega(I_T)}{8\ \Omega + 4\ \Omega} = 1.429\text{ mA},\ I_2 = I_T/2 = 1.0715\text{ mA}$$

$$I = I_1 - I_2 = 1.429\text{ mA} - 1.0715\text{ mA} = \mathbf{0.357\text{ mA}}$$

(b)

4 kΩ   4 kΩ V_2 I_2 −   +

4 kΩ   8 kΩ V_1 I_1 −   +

10 V

$$V_1 = \frac{(8\text{ k}\Omega \| 4\text{ k}\Omega)(10\text{ V})}{8\text{ k}\Omega \| 4\text{ k}\Omega + 4\text{ k}\Omega \| 4\text{ k}\Omega} = 5.715\text{ V}$$

$$I_1 = \frac{V_1}{8\text{ k}\Omega} = 0.714\text{ mA}$$

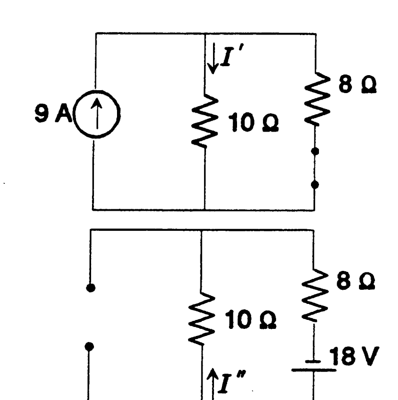
$$V_2 = E - V_1 = 10\text{ V} - 5.715\text{ V} = 4.285\text{ V}$$

$$I_2 = \frac{V_2}{4\text{ k}\Omega} = 1.071\text{ mA}$$

$$I = I_2 - I_1 = 1.071\text{ mA} - 0.714\text{ mA} = \mathbf{0.357\text{ mA}}$$

CHAPTER 9 (Even)

2. a. I:



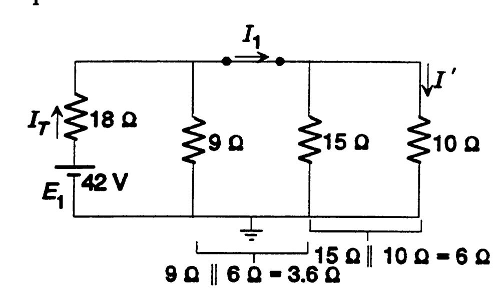
$$I' = \frac{8\ \Omega(9\ \text{A})}{8\ \Omega + 10\ \Omega} = 4\ \text{A}$$

E:

$$I'' = \frac{18\ \text{V}}{10\ \Omega + 8\ \Omega} = 1\ \text{A}$$

$I(\text{dir. of } I') = I' - I'' = 4\ \text{A} - 1\ \text{A} = \mathbf{3\ A}$

b. E_1:

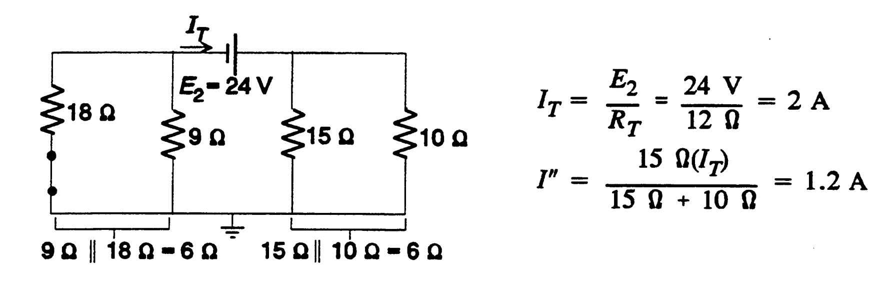


$$I_T = \frac{42\ \text{V}}{18\ \Omega + 3.6\ \Omega} = 1.944\ \text{A}$$

$$I_1 = \frac{9\ \Omega(I_T)}{9\ \Omega + 6\ \Omega} = \frac{9\ \Omega(1.944\ \text{A})}{15\ \Omega} = 1.1664\ \text{A}$$

$$I' = \frac{15\ \Omega(I_1)}{15\ \Omega + 10\ \Omega} = \frac{15\ \Omega(1.1664\ \text{A})}{25\ \Omega} = 0.7\ \text{A}$$

E_2:

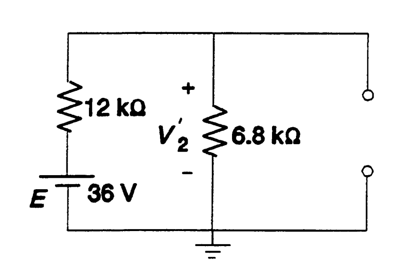


$$I_T = \frac{E_2}{R_T} = \frac{24\ \text{V}}{12\ \Omega} = 2\ \text{A}$$

$$I'' = \frac{15\ \Omega(I_T)}{15\ \Omega + 10\ \Omega} = 1.2\ \text{A}$$

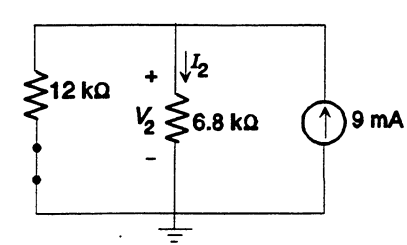
$I_{10\Omega} = I' + I'' = 0.7\ \text{A} + 1.2\ \text{A} = \mathbf{1.9\ A}$

4. E:



$$V'_2 = \frac{6.8\ \text{k}\Omega(36\ \text{V})}{6.8\ \text{k}\Omega + 12\ \text{k}\Omega} = 13.02\ \text{V}$$

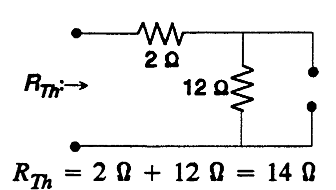
I:



$$I_2 = \frac{12\text{ k}\Omega(9\text{ mA})}{12\text{ k}\Omega + 6.8\text{ k}\Omega} = 5.745\text{ mA}$$

$V''_2 = I_2R_2 = (5.745\text{ mA})(6.8\text{ k}\Omega) = 39.06\text{ V}$
$V_2 = V'_2 + V''_2 = 13.02\text{ V} + 39.06\text{ V} = \mathbf{52.08\text{ V}}$

6. (I) a.



$R_{Th} = 2\ \Omega + 12\ \Omega = 14\ \Omega$

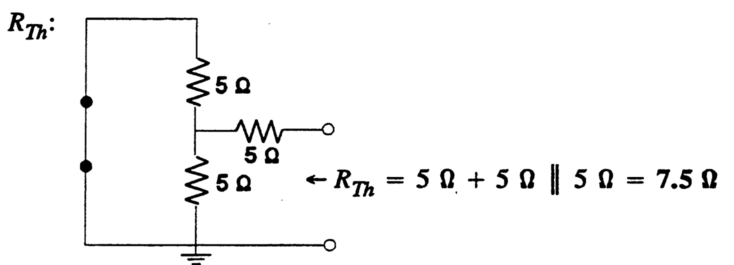
+ V = 0 V -
2 Ω
I = 0
E_{Th}
12 Ω
3 A
3 A

$E_{Th} = IR = (3\text{ A})(12\ \Omega) = 36\text{ V}$

b. $R = 2\ \Omega$: $P = \left[\frac{E_{Th}}{R_{Th} + R}\right]^2 R = \left[\frac{36\text{ V}}{14\ \Omega + 2\ \Omega}\right]^2 2\ \Omega = \mathbf{10.125\text{ W}}$

$R = 100\ \Omega$: $P = \left[\frac{36\text{ V}}{14\ \Omega + 100\ \Omega}\right]^2 100\ \Omega = \mathbf{9.9723\text{ W}}$

(II) a. R_{Th}:



$\leftarrow R_{Th} = 5\ \Omega + 5\ \Omega \parallel 5\ \Omega = \mathbf{7.5\ \Omega}$

E_{Th}:

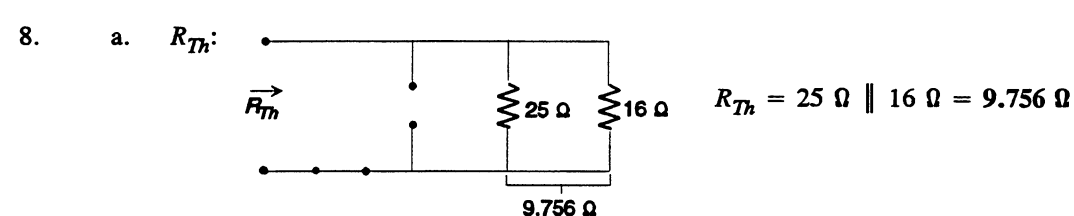
5 Ω
5 Ω
20 V
5 Ω
+
-

$$E_{Th} = \frac{20\text{ V}}{2} = \mathbf{10\text{ V}}$$

b. $R = 2\ \Omega: P = \left[\dfrac{E_{Th}}{R_{Th} + R}\right]^2 R = \left[\dfrac{10\text{ V}}{7.5\ \Omega + 2\ \Omega}\right]^2 2\ \Omega = \mathbf{2.2161\ W}$

$R = 100\ \Omega: P = \left[\dfrac{10\text{ V}}{7.5\ \Omega + 100\ \Omega}\right]^2 100\ \Omega = \mathbf{0.8653\ W}$

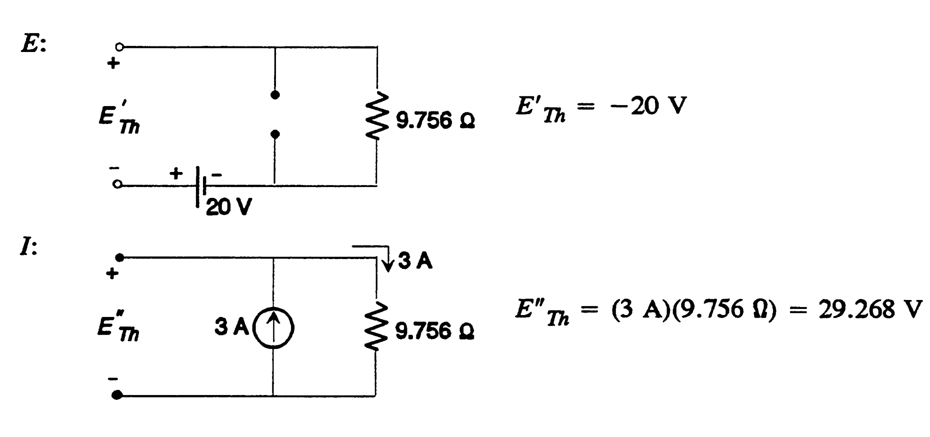
8. a. R_{Th}:



$R_{Th} = 25\ \Omega \parallel 16\ \Omega = \mathbf{9.756\ \Omega}$

E_{Th}: Superposition:

E:



$E'_{Th} = -20\text{ V}$

I:

$E''_{Th} = (3\text{ A})(9.756\ \Omega) = 29.268\text{ V}$

$E_{Th} = E''_{Th} - E'_{Th} = 29.268\text{ V} - 20\text{ V} = \mathbf{9.268\ V}$

b. R_{Th}:

3 Ω, 6 Ω, 4 Ω, 2 Ω

$R_{Th} = 4\ \Omega \parallel (2\ \Omega + 6\ \Omega \parallel 3\ \Omega) = \mathbf{2\ \Omega}$

E_{Th}:

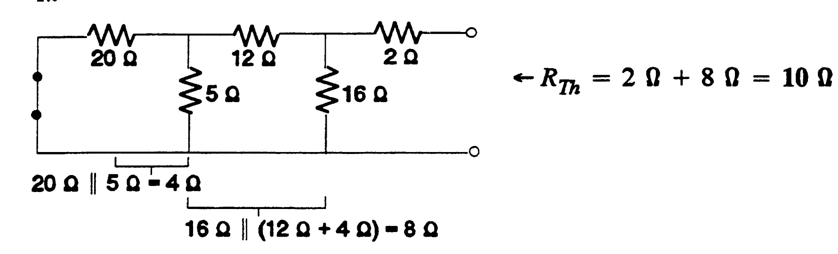
I_T, 72 V, V_6, 6 Ω, V_2, 2 Ω, I_2, 3 Ω, 4 Ω, E_{Th}

$$I_T = \frac{72\text{ V}}{6\ \Omega + 3\ \Omega \parallel (2\ \Omega + 4\ \Omega)} = 9\text{ A}$$

$$I_2 = \frac{3\ \Omega(I_T)}{3\ \Omega + 6\ \Omega} = \frac{3\ \Omega(9\text{ A})}{9\ \Omega} = 3\text{ A}$$

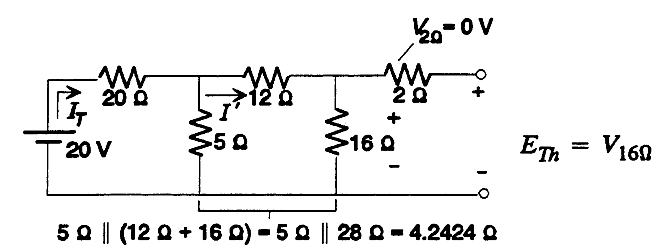
$$E_{Th} = V_6 + V_2 = (I_T)(6\ \Omega) + I_2(2\ \Omega)$$
$$= (9\text{A})(6\ \Omega) + (3\text{ A})(2\ \Omega) = \mathbf{60\ V}$$

10. a. R_{Th}:



$\leftarrow R_{Th} = 2\ \Omega + 8\ \Omega = \mathbf{10\ \Omega}$

E_{Th}:



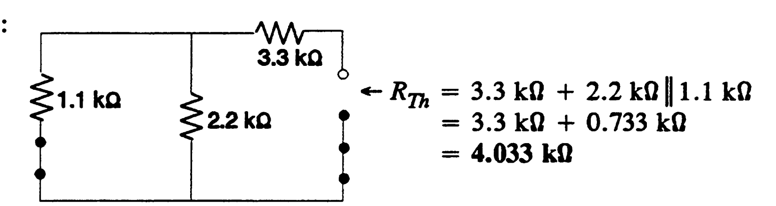
$E_{Th} = V_{16\Omega}$

$$I_T = \frac{20\ \text{V}}{20\ \Omega + 4.2424\ \Omega} = 0.825\ \text{A}$$

$$I' = \frac{5\ \Omega(I_T)}{5\ \Omega + 28\ \Omega} = \frac{5\ \Omega(0.825\ \text{A})}{33\ \Omega} = 0.125\ \text{A}$$

$$E_{Th} = V_{16\Omega} = (I')(16\ \Omega) = (0.125\ \text{A})(16\ \Omega) = \mathbf{2\ V}$$

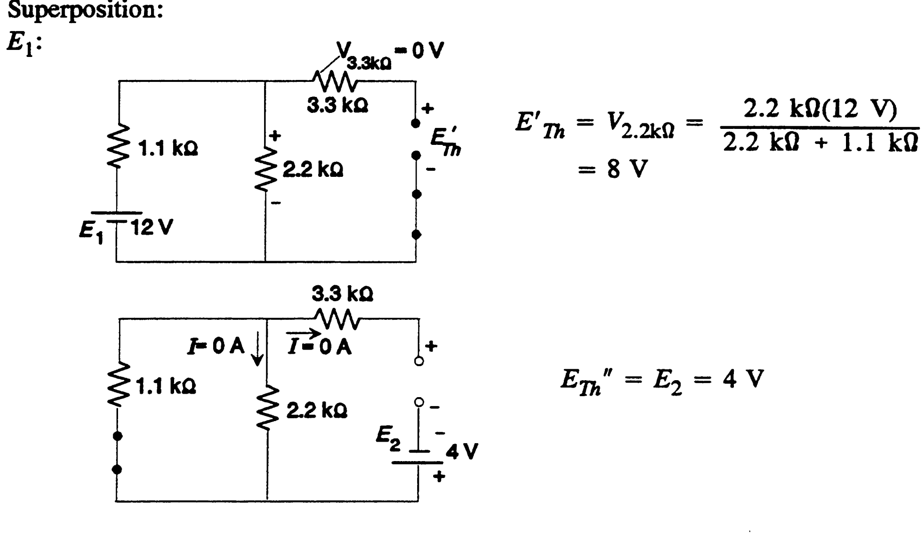
b. 



$$\leftarrow R_{Th} = 3.3\ \text{k}\Omega + 2.2\ \text{k}\Omega \parallel 1.1\ \text{k}\Omega$$
$$= 3.3\ \text{k}\Omega + 0.733\ \text{k}\Omega$$
$$= \mathbf{4.033\ k\Omega}$$

E_{Th}: Superposition:

E_1:

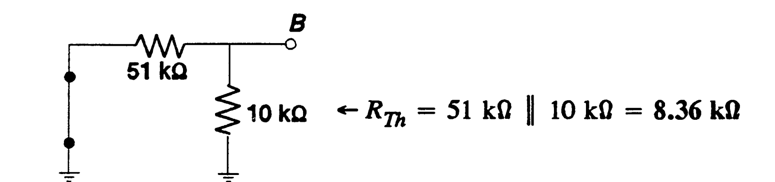


$$E'_{Th} = V_{2.2k\Omega} = \frac{2.2\ \text{k}\Omega(12\ \text{V})}{2.2\ \text{k}\Omega + 1.1\ \text{k}\Omega}$$
$$= 8\ \text{V}$$

$$E_{Th}'' = E_2 = 4\ \text{V}$$

$$E_{Th} = E'_{Th} + E''_{Th} = 8\ \text{V} + 4\ \text{V} = \mathbf{12\ V}$$

12. a. R_{Th}:



$\leftarrow R_{Th} = 51\ \text{k}\Omega \parallel 10\ \text{k}\Omega = \mathbf{8.36\ k\Omega}$

E_{Th}:

$$E_{Th} = \frac{10\ \text{k}\Omega(20\ \text{V})}{10\ \text{k}\Omega + 51\ \text{k}\Omega} = \mathbf{3.28\ V}$$

b. $I_E R_E + V_{CE} + I_C R_C = 20\ \text{V}$

but $I_C \cong I_E$

and $I_E(R_C + R_E) + V_{CE} = 20\ \text{V}$

$$\text{or } I_E = \frac{20\ \text{V} - V_{CE}}{R_C + R_E} = \frac{20\ \text{V} - 8\ \text{V}}{2.2\ \text{k}\Omega + 0.5\ \text{k}\Omega} = \frac{12\ \text{V}}{2.7\ \text{k}\Omega} = \mathbf{4.444\ mA}$$

c.

$E_{Th} - I_B R_{Th} - V_{BE} - V_E = 0$

$$\text{and } I_B = \frac{E_{Th} - V_{BE} - V_E}{R_{Th}} = \frac{3.28\ \text{V} - 0.7\ \text{V} - (4.444\ \text{mA})(0.5\ \text{k}\Omega)}{8.36\ \text{k}\Omega}$$

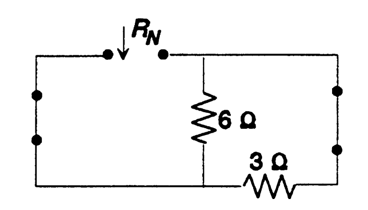
$$= \frac{2.58\ \text{V} - 2.222\ \text{V}}{8.36\ \text{k}\Omega} = \frac{0.358\ \text{V}}{8.36\ \text{k}\Omega} = \mathbf{42.82\ \mu A}$$

d. $V_C = 20\ \text{V} - I_C R_C = 20\ \text{V} - (4.444\ \text{mA})(2.2\ \text{k}\Omega)$

$= 20\ \text{V} - 9.777\ \text{V}$

$= \mathbf{10.223\ V}$

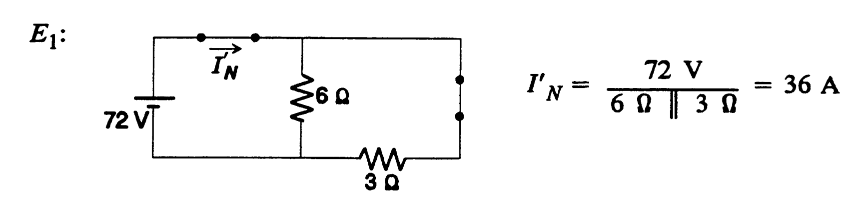
14. (I)(a) R_N:



$R_N = 6\ \Omega \parallel 3\ \Omega = 2\ \Omega$

I_N:

E_1:



$$I'_N = \frac{72\ \text{V}}{6\ \Omega \parallel 3\ \Omega} = 36\ \text{A}$$

E_2:

$$I''_N = \frac{18\ \text{V}}{3\ \Omega} = 6\ \text{A}$$

$$I_N = I'_N + I''_N = 36\ \text{A} + 6\ \text{A} = \mathbf{42\ A}$$

(II)(a) R_N:

$$R_N = 5.6\ \text{k}\Omega \parallel 2.2\ \text{k}\Omega = \mathbf{1.5795\ k\Omega}$$

I_N:

I:

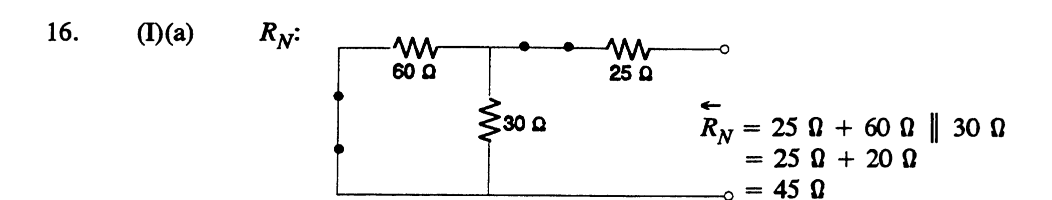
$$I'_N = 8\ \text{mA}$$

E:

$$I''_N = \frac{16\ \text{V}}{2.2\ \text{k}\Omega} = 7.2727\ \text{mA}$$

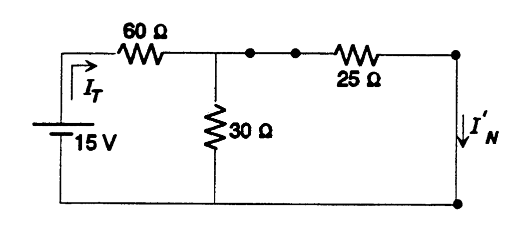
$$I_N \uparrow = 8\ \text{mA} - 7.2727\ \text{mA} = \mathbf{0.7273\ mA}$$

16. (I)(a) R_N:



I_N:

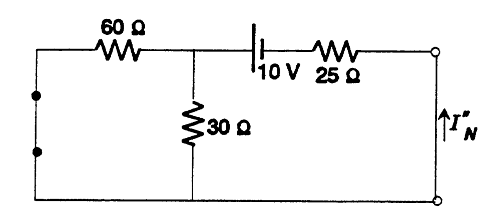
$E = 15$ V:



$$I_T = \frac{15\text{ V}}{60\ \Omega + 30\ \Omega \| 25\ \Omega} = 0.2037\text{ A}$$

$$I'_N = \frac{30\ \Omega(I_T)}{30\ \Omega + 25\ \Omega} = 0.1111\text{ A}$$

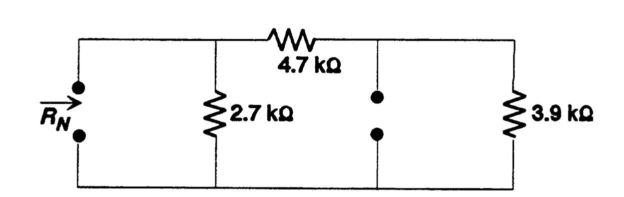
$E = 10$ V:



$$I''_N = \frac{10\text{ V}}{25\ \Omega + 60\ \Omega \| 30\ \Omega} = \frac{10\text{ V}}{25\ \Omega + 20\ \Omega} = 0.2222\text{ A}$$

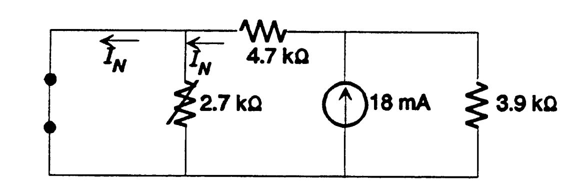
I_N (dir of I''_N) $= I''_N - I'_N = 0.2222\text{ A} - 0.1111\text{ A} = \mathbf{0.111\text{ A}}$

(II)(a) R_N:



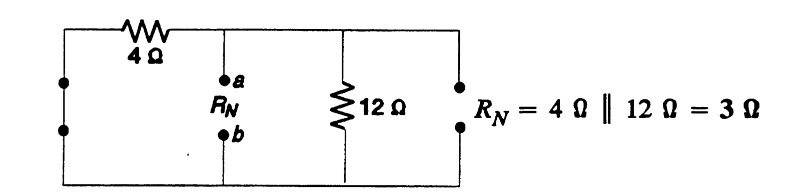
$R_N = 2.7\text{ k}\Omega \| (4.7\text{ k}\Omega + 3.9\text{ k}\Omega) = \mathbf{2.055\text{ k}\Omega}$

I_N:



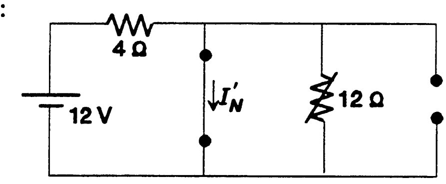
$$I_N = \frac{3.9\text{ k}\Omega(18\text{ mA})}{3.9\text{ k}\Omega + 4.7\text{ k}\Omega} = \mathbf{8.163\text{ mA}}$$

18. a. R_N:



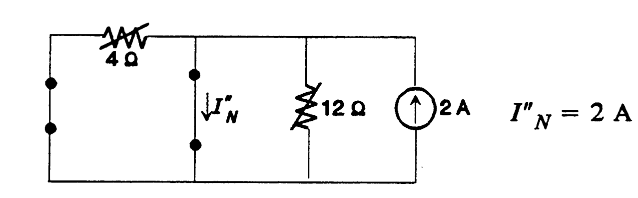
$R_N = 4\ \Omega \parallel 12\ \Omega = \mathbf{3\ \Omega}$

$E = 12$ V:



$I'_N = \dfrac{12\text{ V}}{4\ \Omega} = 3\text{ A}$

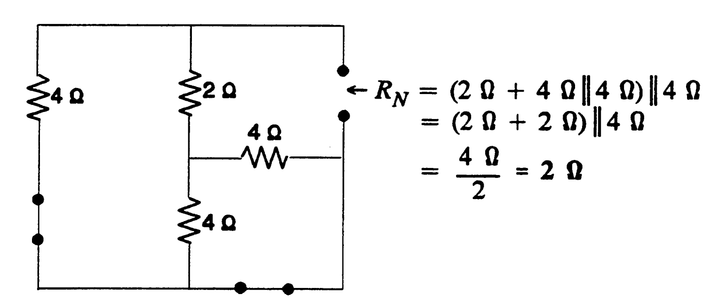
$I = 2$ A:



$I''_N = 2\text{ A}$

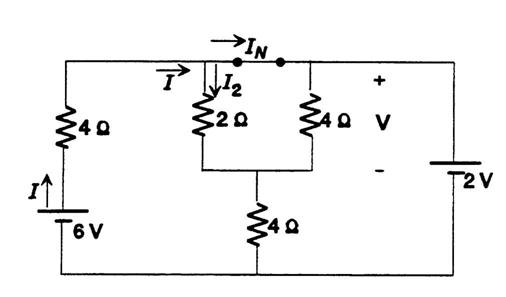
$I_N = I'_N + I''_N = 3\text{ A} + 2\text{ A} = \mathbf{5\ A}$

b. R_N:



$$\begin{aligned} R_N &= (2\ \Omega + 4\ \Omega \parallel 4\ \Omega) \parallel 4\ \Omega \\ &= (2\ \Omega + 2\ \Omega) \parallel 4\ \Omega \\ &= \frac{4\ \Omega}{2} = \mathbf{2\ \Omega} \end{aligned}$$

I_N:



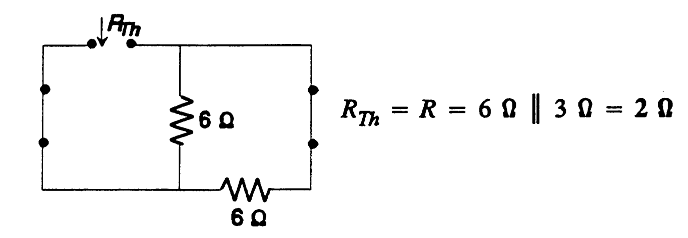
$I = \dfrac{V_{4\Omega}}{4\ \Omega} = \dfrac{6\text{ V} - 2\text{ V}}{4\ \Omega} = \dfrac{4\text{ V}}{4\ \Omega} = 1\text{ A}$

$V = \dfrac{(4\ \Omega \parallel 2\ \Omega)(2\text{ V})}{(4\ \Omega \parallel 2\ \Omega) + 4\ \Omega} = 0.5\text{ V}$

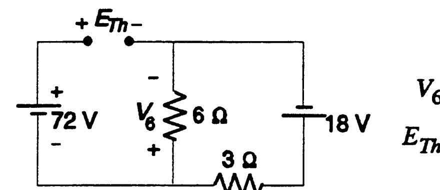
$I_2 = \dfrac{V}{R} = \dfrac{0.5\text{ V}}{2\ \Omega} = 0.25\text{ A}$

$I_N = I - I_2 = 1\text{ A} - 0.25\text{ A} = \mathbf{0.75\ A}$

20. (I) a.



$R_{Th} = R = 6\ \Omega \parallel 3\ \Omega = 2\ \Omega$

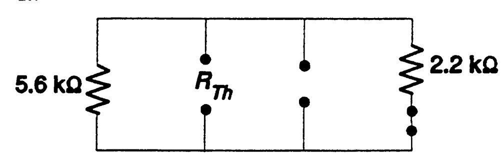


$$V_6 = \frac{6\ \Omega(18\ \text{V})}{6\ \Omega + 3\ \Omega} = 12\ \text{V}$$

$$E_{Th} = 72\ \text{V} + V_6$$
$$= 72\ \text{V} + 12\ \text{V} = \mathbf{84\ V}$$

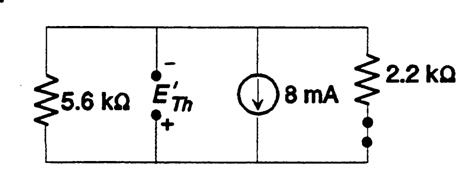
b. $P_{max} = \dfrac{E_{Th}^2}{4R_{Th}} = \dfrac{(84\ \text{V})^2}{4(2\ \Omega)} = \mathbf{882\ W}$

(II) a. R_{Th}:



$R_{Th} = 5.6\ \text{k}\Omega \parallel 2.2\ \text{k}\Omega$
$= \mathbf{1.5795\ k\Omega}$

b. E_{Th}:



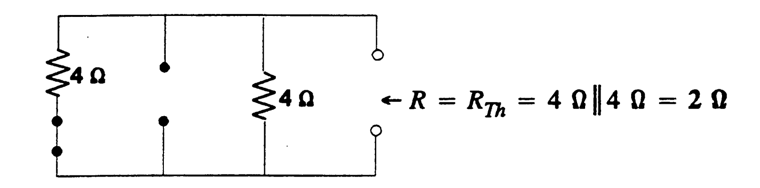
$E'_{Th} = 8\ \text{mA}(2.2\ \text{k}\Omega \parallel 5.6\ \text{k}\Omega)$
$= 8\ \text{mA}(1.5795\ \text{k}\Omega)$
$= 12.636\ \text{V}$

$$E''_{Th} = \frac{5.6\ \text{k}\Omega(16\ \text{V})}{5.6\ \text{k}\Omega + 2.2\ \text{k}\Omega}$$
$= 11.487\ \text{V}$

E_{Th} (polarity of E'_{Th}) $= E'_{Th} - E''_{Th}$
$= 12.636\ \text{V} - 11.487\ \text{V} = \mathbf{1.149\ V}$

$$P_{max} = \frac{E_{Th}^2}{4R_{Th}} = \frac{(1.149\ \text{V})^2}{4(1.5795\ \text{k}\Omega)} = \mathbf{0.21\ mW}$$

22. a.

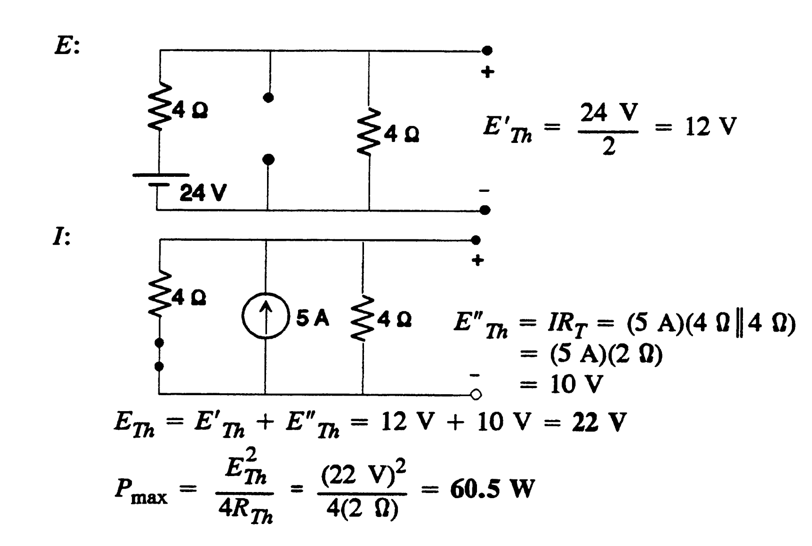


$\leftarrow R = R_{Th} = 4\ \Omega \parallel 4\ \Omega = 2\ \Omega$

b. E_{Th}:

E:

I:



$$E'_{Th} = \frac{24\text{ V}}{2} = 12\text{ V}$$

$$E''_{Th} = IR_T = (5\text{ A})(4\ \Omega \parallel 4\ \Omega) = (5\text{ A})(2\ \Omega) = 10\text{ V}$$

$$E_{Th} = E'_{Th} + E''_{Th} = 12\text{ V} + 10\text{ V} = \mathbf{22\text{ V}}$$

$$P_{max} = \frac{E_{Th}^2}{4R_{Th}} = \frac{(22\text{ V})^2}{4(2\ \Omega)} = \mathbf{60.5\text{ W}}$$

c. R_{Th} I R E_{Th}

$$P = I^2R = \left[\frac{E_{Th}}{R_{Th} + R}\right]^2 R$$

$R = \frac{1}{4}(2\ \Omega) = 0.5\ \Omega$, P = **38.72 W**

$R = \frac{1}{2}(2\ \Omega) = 1\ \Omega$, P = **53.78 W**

$R = \frac{3}{4}(2\ \Omega) = 1.5\ \Omega$, P = **59.27 W**

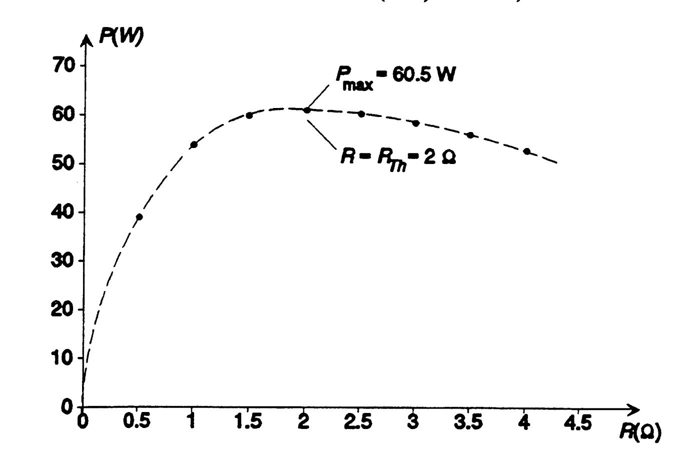
$R = 2\ \Omega$, P = 60.5 W

$R = \frac{5}{4}(2\ \Omega) = 2.5\ \Omega$, P = **59.75 W**

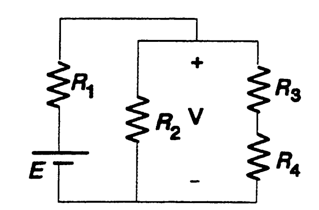
$R = \frac{3}{2}(2\ \Omega) = 3\ \Omega$, P = **58 W**

$R = \frac{7}{4}(2\ \Omega) = 3.5\ \Omega$, P = **56 W**

$R = 2(2\ \Omega) = 4\ \Omega$, P = **53.78 W**



24. a.

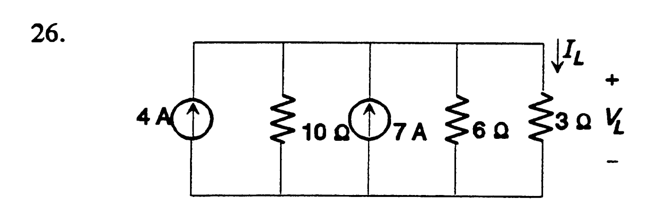


V, and therefore V_4, will be its largest value when R_2 is as large as possible. Therefore choose R_2 = open-circuit (∞ Ω).

Then $P_4 = \frac{V_4^2}{R_4}$ will be a maximum.

b. No, examine each individually.

26.

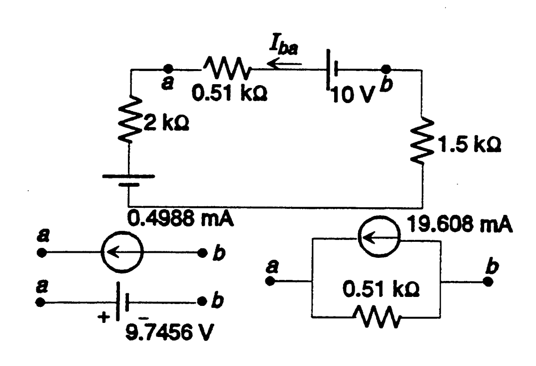


$I_T\uparrow = 4\text{ A} + 7\text{ A} = 11\text{ A}$
$R_T = 10\ \Omega \parallel 6\ \Omega \parallel 3\ \Omega = 1.667\ \Omega$
$V_L = I_T R_T = (11\text{ A})(1.667\ \Omega) = \mathbf{18.34\ V}$
$I_L = \frac{V_L}{R_L} = \frac{18.34\text{ V}}{3\ \Omega} = \mathbf{6.113\ A}$

28. $I_T\downarrow = 2\text{ A} - 0.2\text{ A} - 0.001\text{ A} = 1.799\text{ A}$
$R_T = 200\ \Omega \parallel 200\ \Omega \parallel 100\ \Omega \parallel 10\text{ k}\Omega = 49.751\ \Omega$
$V_L = I_T R_T = (1.799\text{ A})(49.751\ \Omega) = 89.5\text{ V}$
$I_L = \frac{V_L}{R_L} = \frac{89.5\text{ V}}{200\ \Omega} = \mathbf{0.448\ A}$

30. $\overleftarrow{I_{eq}} = \frac{(4\text{ mA})(8.2\text{ k}\Omega) + (8\text{ mA})(4.7\text{ k}\Omega) - (10\text{ mA})(2\text{ k}\Omega)}{8.2\text{ k}\Omega + 4.7\text{ k}\Omega + 2\text{ k}\Omega}$
$= \frac{32.8\text{ V} + 37.6\text{ V} - 20\text{ V}}{14.9\text{ k}\Omega} = 3.3826\text{ mA}$
$R_{eq} = 8.2\text{ k}\Omega + 4.7\text{ k}\Omega + 2\text{ k}\Omega = 14.9\text{ k}\Omega$
$I_L = \frac{R_{eq} I_{eq}}{R_{eq} + R_L} = \frac{(14.9\text{ k}\Omega)(3.3826\text{ mA})}{14.9\text{ k}\Omega + 6.8\text{ k}\Omega} = \mathbf{2.3226\ mA}$
$V_L = I_L R_L = (2.3226\text{ mA})(6.8\text{ k}\Omega) = \mathbf{15.7937\ V}$

32.



$I_{ba} = \frac{10\text{ V} - 8\text{ V}}{2\text{ k}\Omega + 0.51\text{ k}\Omega + 1.5\text{ k}\Omega}$
$= \mathbf{0.4988\ mA}$
$V_{0.51\text{k}\Omega} = (0.4988\text{ mA})(0.51\text{ k}\Omega)$
$= 0.2544\text{ V}$
$V_{ab} = 10\text{ V} - 0.2544\text{ V} = 9.7456\text{ V}$
+-

34. a. $I_s = \frac{24\text{ V}}{8\text{ k}\Omega + \frac{24\text{ k}\Omega}{3}} = 1.5\text{ mA}, I = \frac{I_s}{3} = \mathbf{0.5\ mA}$

b.

$I_s = \dfrac{24 \text{ V}}{24 \text{ k}\Omega + 8 \text{ k}\Omega \| 12 \text{ k}\Omega} = 0.8333 \text{ mA}$

$I = \dfrac{12 \text{ k}\Omega(I_s)}{12 \text{ k}\Omega + 8 \text{ k}\Omega} = \mathbf{0.5 \text{ mA}}$

c. yes

36. a. $I_{R_2} = \dfrac{R_1(I)}{R_1 + R_2 + R_3} = \dfrac{3\Omega(6 \text{ A})}{3 \Omega + 2 \Omega + 4 \Omega} = 2\text{A}$

$V = I_{R_2}R_2 = (2 \text{ A})(2 \Omega) = \mathbf{4 \text{ V}}$

b. $I_{R_1} = \dfrac{R_2(I)}{R_1 + R_2 + R_3} = \dfrac{2 \Omega(6 \text{ A})}{3 \Omega + 2 \Omega + 4 \Omega} = 1.333 \text{ A}$

$V = I_{R_1}R_1 = (1.333 \text{ A})(3 \Omega) = \mathbf{4 \text{ V}}$

c. yes